



# MAGLEV

Read the General Rules in the manuals and on [www.soinc.org](http://www.soinc.org) as they apply to every event.

1. **DESCRIPTION:** Competitors may construct up to two self-propelled magnetically-levitated vehicles with battery-powered motors that turn up to two propellers to move the vehicle(s) down a magnetic track. Competitors must also be tested on their knowledge of magnetism and related topics.

**A TEAM OF UP TO: 2 EYE PROTECTION: #1 IMPOUND: Yes APPROXIMATE TIME: 50 minutes**

2. **EVENT PARAMETERS:**

- The event has two parts: Part 1 - vehicle testing, and Part 2 - written test on magnetism concepts.
- For Part 1, the vehicle(s) and any material needed to adjust the vehicle(s) (e.g., extra magnets, shims, masses, batteries, etc.) must be impounded prior to the start of competition. Competitors may bring their own maglev track to use during their run. Teams may share tracks, but must have different vehicles. Supervisors must check the track specifications before use. Tools and the track need not be impounded.
- For both parts, all reference materials must be secured in a 3-ring binder, must be 3-hole punched and inserted in the binder so that regardless of orientation, none can fall out.
- Competitors must wear eye protection during set-up and testing of their vehicle(s). Teams without proper eye protection must be immediately informed and given a chance to obtain eye protection if time allows. If not, teams are not allowed to compete in Part 1.

3. **CONSTRUCTION:**

- Vehicles may be made of any material, but must meet all specifications and cannot damage the track.
- The length of the vehicle must be between 15.0 and 22.0 cm and cannot vary during the run. Vehicles, excluding dowel (see 3.g), must be less than 20.0 cm tall with the propeller in motion when non-levitated.
- The mass of the vehicle (including batteries and dowel) must be no less than 250.0 grams.
- If a team does not provide their own track, their vehicle must fit on a standard track (width = 2 9/16").
- Vehicles are recommended to have adjustable width to accommodate track variations (e.g. shims, tape).
- The entire vehicle, except for the propeller(s), must not extend outside of the vertical planes defined by the inside edge of the side rails of the track.
- The vehicle must either have a 30.0 cm long 1/8" diameter dowel vertically attached to it within 5.0 cm of its front edge or be able to accommodate an event supervisor-provided dowel of the same dimension.
- Commercial batteries, not exceeding 9.0 V as labeled, may be used to energize the motor(s) on the vehicle. Multiple batteries may be connected together as long as the expected voltage across any points does not exceed 9.0 V as calculated by their labels. The vehicle must not have any other energy sources.
- Vehicles may have up to two propellers and two motors. Motors must have a cross-sectional diameter or diagonal  $\leq 3.5$  cm. Ducted motor/propeller combinations must have a diameter  $\leq 6.0$  cm.
- Brushless motors and integrated circuits are not permitted.
- Any magnets, except rare earth magnets, may be used on the vehicle, but competitors must be able to modify the placement of the magnets so that the vehicle can travel in either direction on the track.
- The vehicle must be levitated as it moves down the track (inadvertent contact is permitted). Competitors must demonstrate that their vehicle levitates by pushing the vehicle slightly down.

4. **THE TRACK:** More information is provided on the event page on [www.soinc.org](http://www.soinc.org)

- The competitor-provided track must be a non-electrified track  $\geq 4$  feet long and have an inside width between 2.0" and 3.0". On longer tracks, a 4-foot (1.22 m) segment must be marked for the competition.
- Event supervisors must provide at least one track for teams who do not bring a track or whose track does not meet specifications. This track must be a standard width track (2 9/16" between inner faces of rails).
- The height of the inside edge of the side rails measured from the top of the magnets to the top of the railing must be between 2.00 cm and 5.00 cm.
- In advance of the competition, supervisors are encouraged to provide details of their track.
- Both commercially-produced tracks and hand-made tracks are allowed. Instructions for making various tracks are available on the event page on [www.soinc.org](http://www.soinc.org).
- The track must be placed on a flat level surface with enough room to allow a cushioned barrier to be placed at the end of the track and 25 cm beyond to prevent the vehicle from being damaged.

## 5. THE COMPETITION:

### a. Part 1: Vehicle Testing

- i. The length of the timed portion of the track is between 50.0 and 95.0 cm, in 1.0 cm increments. The event supervisor must announce the exact length after impound, which will be the same for all teams. Supervisors must mark the distance on all tracks with both start and finish lines.
- ii. Competitors must have a total of 8 minutes to first predict the run time of their vehicle(s) (only 1 prediction allowed), then orient their vehicle(s) appropriately, adjust and repair their vehicle(s), and make two successful runs on the track (as described below). Vehicles that do not meet the construction specs must not be allowed to run until brought into spec.
- iii. Competitors must place their vehicle on the track directly before the start line of the timed portion. They must place a pencil in front of their vehicle to keep it from moving.
- iv. When ready, competitors may turn on their motor(s) and indicate that their vehicle is ready.
- v. Competitors must not touch their vehicle after they have turned on their motor(s).
- vi. Supervisors are encouraged to use photogates for more precise timing and use at least one back-up manual timer. If only manual timers are utilized, 3 independent timers are recommended on all runs. The middle value of the 3 timers must be the officially recorded time and times must be truncated to the tenth of a second. If the stopwatch shows a hundredths digit, it must be ignored or dropped.
- vii. The judge must give a countdown of "3, 2, 1, launch". The competitors must then release their vehicle by removing the pencil and stepping away from the track. If being manually timed, timing will start when the dowel crosses the start line and stop when it crosses the finish line.
- viii. Both runs may be done with one vehicle or competitors may use different vehicles for each of the two runs. A run must count as long as it is started before the 8-minute period elapsed.
- ix. If a vehicle fails to move after 3 seconds, or moves only part of the way down the track, competitors must be allowed to restart their vehicle without penalty any number of times within the 8-minute window until two successful runs have been completed. Additional successful runs are not allowed.
- x. If, during a run, any part of the vehicle falls off, the run must not be counted and the team will be allowed to repair and restart their vehicle or replace it with another impounded vehicle.
- xi. Teams filing an appeal regarding Part 1 must leave their vehicle(s) and track in the competition area.

### b. Part 2: Written Test

- i. All answers must be provided in SI units with appropriate significant figures.
- ii. Teams must be given a set amount of time (20 – 30 minutes is suggested) to complete a written test.
- iii. Topics that may be included are: polarity, Earth's magnetic field, electromagnetic principles, magnetic vs. non-magnetic materials, common uses of magnets, the history of the theories of magnetism and magnetic technology, superconducting maglev transportation technology, magnetic force, electric motors/generators, solenoids, magnetic domains, permanent magnets, ferromagnetic materials, medical uses of magnets, and superconductors.

## 6. SCORING: A scoring rubric is available on the event page on [www.soinc.org](http://www.soinc.org)

- a. Vehicle Score (VS) = total mass of vehicle / run time (RT) to travel the timed portion
- b. Run Score (RS) = (team's best VS / the highest VS at the competition) x 50 points
- c. Teams whose vehicle(s) only move partially down the track get a RS = 0. Teams whose vehicle(s) do not move past the start line or attempt any runs get a RS = -10. Teams that fail to impound get a RS = -20.
- d. Time Score (TS) =  $(1 - (\text{abs}(\text{RT} - \text{predicted time}) / \text{RT})) \times 10$  points. The RT used must be from the run with the best VS. The smallest possible TS is 0. Teams with no successful runs receive a TS of 0.
- e. Exam Score (ES): The test used for Part 2 of this event must be worth 50 points.
- f. Penalties: 2 points each time a Competition section requirement is violated; 10 points for each Construction section requirement violation.
- g. Final Score (FS) = RS + TS + ES - Penalties. The maximum possible FS is 110 points. High score wins.
- h. Tie Breakers: 1<sup>st</sup> - Best RS; 2<sup>nd</sup> - Best ES; 3<sup>rd</sup> - Best TS; 4<sup>th</sup> - Best 2<sup>nd</sup> VS (VS not used for RS calculation); 5<sup>th</sup> - specific test questions

**Recommended Resources:** All reference and training resources including the **MagLev DVD** and the **Problem Solving/Technology CD** are available on the Official Science Olympiad Store or Website at [www.soinc.org](http://www.soinc.org)